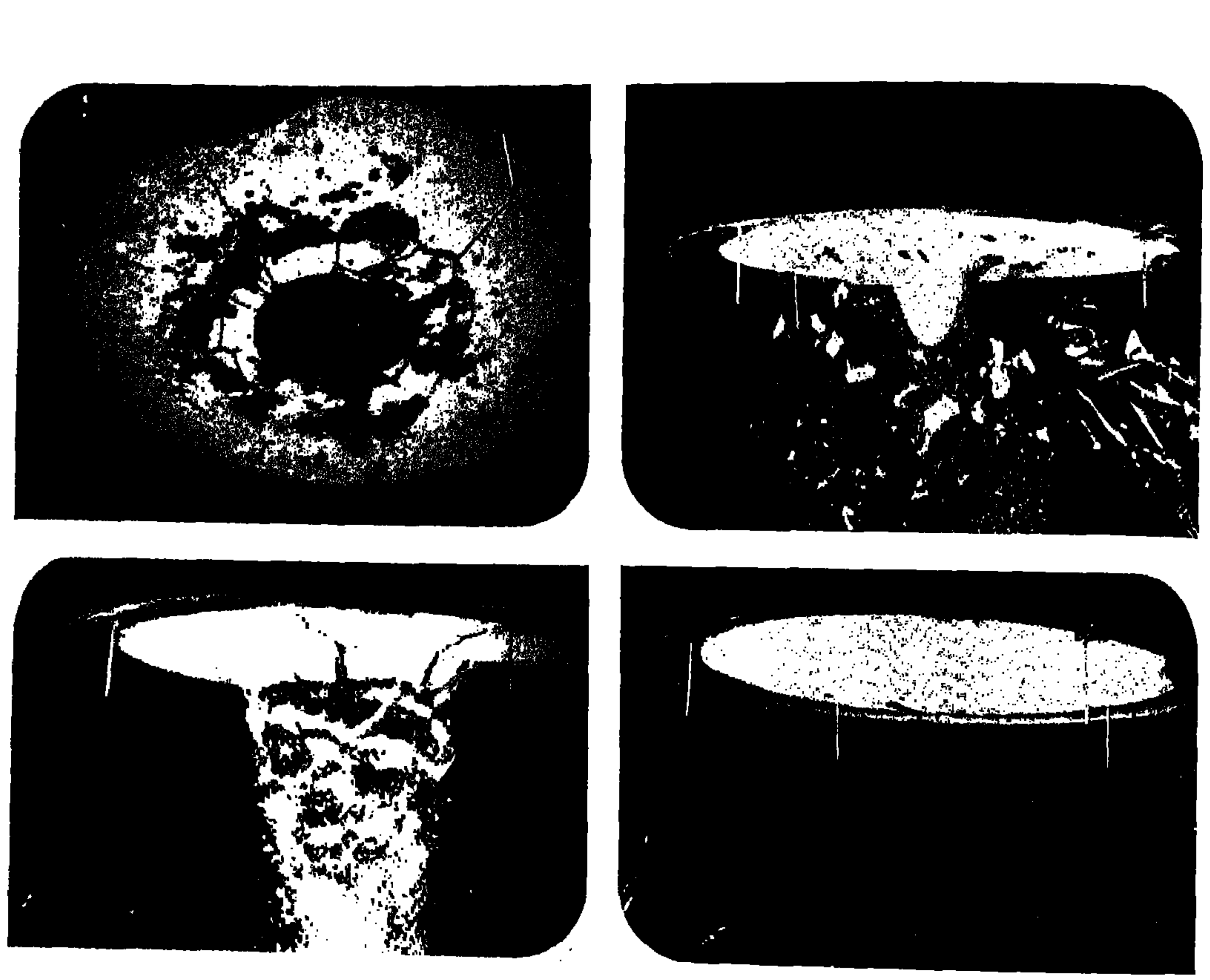

EOS
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Physical Properties of Rocks

6120 Elasticity, fracture, and flow
THEORY OF TIME-DEPENDENT RUPTURE IN THE EARTH
S. Das (Lamont-Doherty Geological Observatory of Columbia University, Palisades, New York 10964) and C. H. Scholz (also at: Dept. Geological Sciences, Columbia University)

Using the concepts of fracture mechanics, we develop a theory of the earthquake mechanism which includes the phenomenon of subcritical crack growth. The theory specifically predicts the following phenomena: slow earthquakes, multiple events, delayed multiple events (doublets), postseismic rupture growth and afterslip, foreshocks, and aftershocks. The theory also predicts that there must be a nucleation stage prior to an earthquake, and suggests a physical mechanism by which one earthquake may 'trigger' another.

These predictions are obtained by combining two fundamental concepts. The first is that

K = G [illegible]

and the second, that

$$v = v_0 \left(\frac{K}{K_0}\right)^{1/n}$$

where K is the stress intensity factor, [illegible] stress drop, L rupture length, v rupture velocity, C a geometrical factor, and K_0, v_0, and n are material constants. The first is a fundamental result of fracture mechanics; the second describes stress corrosion cracking, a well established physical process that results in subcritical crack growth.

We investigate in detail the phenomena of [illegible] which are [illegible] predicted by [illegible] fracture mechanics: nucleation and delayed multiple events. In the first case we find that all earthquakes must be preceded by [illegible] a portion of their rupture [illegible] it may be difficult to detect in [illegible]. In the second case we studied two pairs of delayed multiple events that were separated by the same 'barrier' in order to calculate n. We find that the stress corrosion index, n [illegible] critical crack growth [illegible] delayed multiple events.

[illegible] Res., Red, Paper [illegible]

6165 Magnetic and electrical properties of rocks
CHARACTERIZATION OF VISCOUS REMANENT MAGNETIZATION IN SINGLE- AND MULTI-DOMAIN MAGNETITE GRAINS
M. [illegible] (Dept. of Oceanography, WB-10, Univ. of Washington, Seattle, WA 98195) H. P. Johnson

Viscous remanent magnetization acquisition and decay coefficients are shown to be strongly affected by the previous magnetic history of the samples. Demagnetization of coarse grain, multi-domain, magnetite samples using alternating magnetic fields causes a sharp reduction in the ability to acquire viscous magnetization. VRM acquisition in single-domain particles is not affected by AF demagnetization but is sensitive to the amount of time the sample is kept in zero magnetic field storage prior to applying the VRM field. VRM acquisition coefficients are strongly dependent on magnetic grain size with high values at both very small and very large grain diameters. (Viscous remanent magnetization, magnetite particles, magnetic domain structure).
Geophys. Res. Lett., Paper 1L0160

Planetology

6510 Atmospheres/Planets
OPTICAL SEARCH FOR LIGHTNING ON VENUS
William J. Borucki (Theoretical and Planetary Studies Branch, Ames Research Center, NASA, Moffett Field, California 94035), John W. Dyer, George Z. Thomas, Jerr C. Jordan, and David A. Comstock

Electrical signals attributed to lightning events on Venus have been reported by instruments aboard Veneras 11 and 12 [Ksanfomality, 1980] and aboard the Pioneer Venus Orbiter [Taylor et al., 1979]. This paper reports the results of a search for optical pulses from the dark side of Venus made with the star sensor aboard the Pioneer Venus Orbiter. A comparison of both the frequency and amplitude distributions of measured pulses with those of control experiments in which the star sensor observed deep space showed no statistically significant differences. Based on observations made during orbits 300 through 345, an upper limit of 30 flashes/km²/yr has been derived for the average lightning frequency on the dark side of Venus. This value assumes that the amplitude distribution of lightning and the attenuation of the optical pulse by clouds on Venus are not substantially different from that occurring on Earth.
Geophys. Res. Lett., Paper 1L0258

6530 Gross properties of planets
METEOROLOGICAL EFFECTS ON THE SEASONAL VARIATIONS OF THE ROTATION OF MARS
A. Cazenave and G. Balmino (Groupe de Recherches de Géodésie Spatiale, Toulouse, France)

We have investigated the meteorologically induced seasonal variations in the rotation rate of Mars. As on Earth, meteorological effects are expected to produce fluctuations in the rotation of Mars but unlike on Earth, where zonal winds are the major contributors, on Mars seasonal variations are mainly the result of exchange of CO_2 between atmosphere and polar caps through a variation of the polar moment of inertia.

From Viking pressure data and zonal winds models by Haberle et al. [1979] we predict an annual and a semi-annual cycles in the relative rotation rate of Mars of amplitude $\sim 0.2 \times 10^{-8}$ and 0.1×10^{-8} respectively. On the length of the martian day these seasonal changes are 0.17 ms and 0.09 ms respectively. Between the fall equinox and winter solstice (northern hemisphere), the maximum change in the martian l.o.d. amounts to 0.44 ms.
Geophys. Res. Lett., Paper 1L0172

Seismology

6940 Phenomena related to earthquake prediction
UNUSUAL ANIMAL BEHAVIOR BEFORE EARTHQUAKES: A REVIEW OF POSSIBLE SENSORY MECHANISMS.
R.E. Buskirk (Univ. Texas Marine Science Inst., 700 The Strand, Galveston, TX 77550) C. Frohlich and G.V. Latham

To determine whether reports of unusual animal behavior before earthquakes are plausible, we have compared these reports with recent laboratory studies of animal sensory thresholds. Our major conclusion is that some animals are much more capable than humans at perceiving certain kinds of geophysical stimuli which may precede earthquakes. These geophysical stimuli are: seismic or acoustic waves at low frequency (below 50 Hz), electric field changes, and olfactory stimuli. For example, recent studies suggest some birds and fish are more sensitive than humans to sounds with frequencies below 40 Hz, and many animals are exceptionally good at perceiving low frequency vibrations through their skin. Certain fish are sensitive to electric field changes as small as 10^{-5} V/m, and some laboratory mammals also respond to significantly weaker fields than humans. For these electric and acoustic stimuli, the reported levels of geophysical precursors are within the reported perceptible range of some animals which show unusual behavior prior to earthquakes. In addition, stimuli caused by the release of gases from small cracks may well be perceived by some animals before earthquakes. Recent research has confirmed the remarkable olfactory sensitivity of some animal species, but no quantitative comparisons with geochemical precursors can be made yet. We find no evidence that magnetic field precursors or precursory high frequency (above 10 kHz) sounds are the cause of unusual animal behavior before earthquakes. Although some animals are highly sensitive to these stimuli, observed magnetic precursors tend to be of low amplitude amid relatively high noise levels, and high frequency sound is severely attenuated within a short distance from the earthquake hypocenter.

Knowledge of animal sensory capabilities may suggest an instrumental strategy for detecting earthquake precursors. We recommend further geophysical research in seismic areas to measure: (1) seismic waves in the frequency range of 10 to 50 Hz, (2) earthquake-related electric field changes and air ionization, (3) coseismic or preseismic release of trapped gases other than radon. Further biological research can refine our understanding of: (1) responses to sounds and vibrations with frequencies below 50 Hz, (2) the effects of electrical and electrostatic changes on animal behavior, (3) behavioral responses to odors, and (4) sensory capabilities of common domestic animals like horses, dogs, and chickens, which are seldom studied but commonly mentioned in the pre-earthquake reports (earthquakes, precursors, animal behavior, sensory thresholds).
Rev. Geophys. Space Phys., Paper 1R0089

6975 Structure of the earth's interior below the upper mantle
AMPLITUDES OF DIFFRACTED LONG PERIOD P AND S WAVES AND THE VELOCITIES AND THE Q STRUCTURE AT THE BASE OF THE MANTLE
A.H.G. Mula (Geology Department, University of Khartoum, Khartoum, Sudan)

Frequency and time domain analysis of amplitudes of long period (~20 sec) P and S waves diffracted around the earth's core and registered at the WWNSS and CSN stations show that the velocities at the base of the mantle have slightly positive gradients. This result substantiates the previous ray parameter study of Mula and Müller (1980). Such velocity gradients at the base of the mantle imply that there is no significant departure from homogeneity and/or adiabaticity of the base of the mantle from the rest of the lower mantle as suggested by e.g. Bolt (1972), Jones (1977), Jeanloz and Richter (1979) and Doornbos and Mondt (1979).

In addition to this the Q factor for the base of the mantle is found not to be less than 250.
J. Geophys. Res., Red, Paper 1B0115

Editorial

Education and Human Resources

The Committee on Education and Human Resources is charged with recommending to the AGU Council programs which will attract good students into geophysics, assist them in finding appropriate educational opportunities, and later help in identifying employment opportunities. This committee has the potential to be very important to the membership of AGU. We, the newly appointed members, have written this editorial to remind the AGU membership of this committee's existence and to solicit your ideas and advice so that we might achieve this potential.

One of the committee's recent projects has been the overseeing of a booklet entitled 'Careers in Geophysics,' aimed at the college undergraduate. The booklet tells what geophysicists do, what training they need, and where students can go for further information. Currently in press, 'Careers in Geophysics' will be available at no charge from AGU and should be a valuable recruiting tool. Another committee project included the determination of the value of classified advertising in *Eos*. By polling advertisers, this committee determined that the classified ads attract qualified candidates 80% of the time. The weekly nature and the short lead time for publication were emphasized as important. The study also showed that whereas advertising in journals such as *Eos* attracted 35% of successful applicants, personal contacts ultimately led to the filling of 49% of positions. The committee is also supporting the creation of a Roster of Women in the Geoscience Professions by the American Geological Institute (AGI) Women Geoscientists Committee. This roster will include women from all sections of the AGU; such inclusion will be on a voluntary basis. Forms will be distributed via *Eos* in the spring.

There are two subcommittees, one on minority participation in geophysics and one on women in geophysics. Both are charged with recommending, developing, and assisting in the implementation of programs to encourage career opportunities that will lead to significantly greater participation of these groups in the geophysical sciences. The most visible responsibility of the minority subcommittee is representing the AGU in the AGI minorities scholarship program. The most visible responsibility of the women's subcommittee is organizing the Women in Geophysics meeting at each AGU meeting.

What programs or policies do you feel our committee could implement to help you? We feel that one of our most pressing problems is how to attract good students into geophysics. One popular suggestion is to encourage the summer employment of undergraduates from disciplines other than geophysics. Do you have experience in this regard? What should the role of the AGU be in this process, informational only, or as a clearinghouse, matching students and employers? Have any other methods of attracting students worked for you? More generally, should AGU provide space for employers to interview potential employees at each AGU meeting? Would the provision of day care at AGU meetings allow you to attend a meeting that would be difficult for you to attend if it were not provided? Do you have suggestions as to how AGU should arrange it—what to look for and what to avoid? Should there be more structure added to the Women in Geophysics meeting? Should there be scheduled speakers and panelists? What topics should be addressed?

AGU currently has no program in geophysics education. Should we? Should there be articles on geophysics education in *Eos?* Should the AGU prepare an index of the institutions that teach courses in subjects of interest to the various sections of the AGU? Should the AGU prepare model curricula to prepare students for the various disciplines within geophysics? Should the AGU volunteer as a third party in tenure disputes, academic unit reviews, etc.? There are many things that could be done, but we will only have the opportunity to do a subset of these, and we want our activities to reflect the interests of the Union. Therefore, we solicit your advice.

Committee on Education and Human Resources
Christopher T. Russell, Chairman
Chester W. Anderson, III
Aviva Brecher
W. David Cummings
James King, Jr.
Louise Levien
Robert C. Liebermann
Constance A. Sancetta
K. O. Whitfield

Southern California Uplift— Is It or Isn't It?*

John B. Rundle
Sandia National Laboratories
Albuquerque, NM

Marcia McNutt
U.S. Geological Survey
Menlo Park, CA

The Southern California session of the fall 1980 John Muir Geophysical Society meeting was an attempt to answer the question of whether the Southern California Uplift was real tectonic deformation or merely an artifact of systematic survey errors. The three principal speakers were D. D. Jackson (UCLA), W. E. Strange (National Geodetic Survey), and R. Stein (Lamont-Doherty—formerly with the U.S. Geological Survey). Jackson and Strange were arguing the negative side, i.e., that the uplift did not exist, while Stein argued that the uplift was real.

In leveling, observations are made so as to determine the height of permanent benchmarks, typically a kilometer or so apart relative to each other. Attempts are made to locate the marks on competent rock, although it is sometimes the case that marks are in fact placed in unconsolidated alluvium or in other soft ground, leading to unwanted instability. Additionally, real displacements are sometimes seen in alluvia that derive from nontectonic causes, such as water withdrawal.

In connecting one benchmark to another, two 3.2-m rods and a transit level are used. Initially rod 'A' is placed upon the benchmark, while rod 'B' is erected on solid ground a few tens of meters away. The distance between rods is set by leveling standards and atmospheric and slope conditions. Prior to 1965, the interrod distance could be more than 120 m, but since the mid-1960's, the distance is generally held to perhaps half the pre-1960 amount. The level is set roughly midway between the two rods, and several sightings are made on the graduated divisions scribed on each rod. Because both level and rods are erected as near vertical as possible, a calculation of the height difference between rods can easily be made. Rod 'A' is then leapfrogged up the slope several tens of meters beyond rod 'B,' and the measurement process is repeated. This continues until the required benchmark is reached.

As leveling progresses, many checks are made on the self-consistency of the measurements. For example, in double-run leveling, a crew starts at benchmark 1, levels to benchmark 2, then levels back to benchmark 1. If the agreement is not satisfactory, the measurements are repeated. Another check is the closure of observed loops (cover). If leveling were carried out around the loop Saugus-Lebec-Bakersfield-Mojave-Palmdale-Saugus, for example, the net elevation change ought to be zero, unless tectonic or artificially induced motion has occurred during the survey. It is obvious, however, that if a systematic height-proportional error exists in the measurement process, neither of the above checks will suffice to detect it.

Jackson's thesis was that the uplift is a result of systematic errors. Miscalibration of the invar rods, amounting to several parts in 10^4, can be documented, and refraction errors are presumed to occur as well. Looking principally at the line segment Burbank-Saugus-Palmdale over the years 1955-1965, Jackson pointed out that the elevation change is approximately 1 km and that much of the leveling route runs over alluvium, particularly in the Saugus Valley, and may therefore be subject to some nontectonic tilt. Additionally, if one of the rods is miscalibrated, the effect should show up in a scatter plot of apparent tilt between successive surveys against slope, the horizontal derivative of absolute elevation. In general, most of the points fall between two bounding lines with slopes of 10^{-3} and 10^{-4}. Some of the scatter plots showed much better linear trends than others, and in some cases the slope of the regression line was determined by two or three outlying points.

The observed correlation between tilt and slope could be caused by true ground motion, or by systematic errors such as rod miscalibration or refraction. Tectonic motion would not be expected to follow topography so closely, especially since topography is influenced largely by erosion, but local subsidence could produce tilts that are strongly correlated with slope. In at least two cases the correlation must be caused by rod miscalibration because the sign of the tilt/slope ratio changed where rod changes were made. These changes took place at Saugus in 1964 and near the present site of Pyramid Lake in 1965. One rod pair used in 1964 between Saugus and Palmdale has messed up other leveling as well and has even been recognized as faulty by the NGS. This rod was not involved in the change at Pyramid, so that flagrant calibration errors ($>10^{-4}$) exist in at least two rod pairs. The question that remained was whether other rods are seriously miscalibrated and whether true tectonic tilting remains after correcting for these errors. Jackson found that any residual tilts were not statistically significant, except in those cases where the tilt/slope ratio was determined by a few outliers.

Strange began his talk by asserting that rod error could not possibly be the cause of the uplift. Prior to 1916, wooden rods with inscribed brass strips were used, and calibration was the responsibility of the National Bureau of Standards. From 1916-1966, the United States Coast and Geodetic Survey maintained the rods. During 1916-1923, the USCGS calibrated the rods, but after 1923 responsibility returned to NBS. The rods in use from 1916-1929 were generally poorly scribed, but from 1929-1966 the rods were well scribed. Since 1966, rods have been obtained from the Kern Company and are calibrated by the NBS.

The standards of accuracy in use from 1923-1964 were that rods should be calibrated at 1-m intervals and should be correct to ± 100 ppm. From 1964 to the late seventies, calibrations were performed at 10-mm intervals and should have been correct to ± 30 ppm. Presently each division (10 mm) is calibrated to the ± 1-ppm level. Calibration records of old rods showed that standards were met or exceeded. Rods made in 1931-1936 were found to be generally 40 ppm short, whereas rods from 1940-1950 were generally accurate to a few tens of ppm. Note that an error of 40 ppm corresponds to about 40 mm/km of elevation error. Note also that invar, which was originally chosen for its thermal stability, is dimensionally unstable at the level of a few tens of ppm, with a tendency to lengthen with time. Since the errors found in the old rods appear to be at or below specification in general, Strange concluded that systematic error caused by rod miscalibration could not be the cause of the uplift.

The error source that Strange favors as the probable cause is atmospheric refraction. Refraction occurs when the air near the ground becomes stratified because of temperature gradients, being hottest at ground level. The problem was studied in the '30's independently by Kukkamaki and Best. Both derived corrections for atmospheric refraction that depend linearly on the average temperature gradient between 0.5 and 2.5 m above ground level, linearly upon the measured height difference, and quadratically upon the sight length, the distance between transit level and rod. The principal uncertainty appears to be in the determination of the temperature gradient. Since nearly all of the leveling to date has not included temperature measurements, various schemes have been devised to estimate it, based on cloud cover, sun angle, time of day, and so on. The method selected by Strange was based mainly upon empirical considerations and was chosen partly to null elevation changes observed over the line Caliente to Mojave from 1953-1973.

In order to validate the importance of atmospheric refraction, the NGS has recently carried out a series of tests at Gaithersburg, Maryland, and Tucson, Arizona. At Gaithersburg, 218 observations of a 2-m nominal elevation distance were carried out over sight lengths of 30 m, 45 m, and 60 m. Similarly, 238 observations were carried out at Tucson over the same sight lengths of the same elevation difference. At both sites, the observations were taken under a great variety of wind and atmospheric conditions. The observed elevations varied by as much as 65 mm from the nominal at Gaithersburg and 159 mm from the nominal at Tucson for the 60-m sight length; Strange therefore concluded that refraction exists and is probably a significant effect.

When refraction corrections were applied to the Southern California data set, most of the measured uplift went away. The only significant deformation remaining was localized near the San Andreas fault and in Cajon pass. As a self-consistency check, corrected and uncorrected closures were computed. In all cases, the application of refraction corrections did not significantly degrade the closure errors, although many closures were not significantly improved either.

*A summary of the Southern California session of the John Muir Geophysical Society Meeting, October 6-8, 1980, Asilomar, California.

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Cover. Cumulative uplift in southern California from 1959 through 1974. Elevation change contours taken from leveling data along lines shown, additional lines extending eastward and westward from the net shown, and the results from levelings commissioned especially to document the eastern extent of the bulge. (From *United States Geological Survey Yearbook*, p. 92, 1977).

Thus, corrected deformations are at least as plausible as uncorrected deformations, if closure error is the criterion.

Stein contended that Jackson had grossly overestimated the impact of levelling rod error and argued that Strange's refraction correction has yet to be adequately tested. Stein showed that when tilt measured from resurvey was plotted as a function of topographic slope for 1100 km of routes that are too steep for significant refraction, the mean rod-related elevation-dependent error comes to $(0 \pm 5) \times 10^{-6} \times$ the topographic height. In other words, the standard error for levels run over 1000-m topography is about 5 cm. The relevels spanned the years 1953–1980; during this period the mean error was about constant. The error tends to cancel over several relevels of a route or over more than about 80 km along one route. Since the error does not accumulate, it could not cause the 20–30-cm errors that would be required to interpret the uplift as a rod artifact.

Stein showed that when rod-related errors were removed from a sequence of relevels across the uplift, 149 ± 17 mm of uplift results at Grapevine, north of the San Andreas fault at Tejon Pass, relative to Saugus, at the base of the San Gabriel Mountains, compared to 165 ± 9 mm, using observed data. Strange applies less than 10 mm of refraction correction on those resurveys since the sight lengths were short and nearly the same for all relevels, so this measure of uplift is independent of optical effects.

In his comments on Strange's presentation, Stein first pointed out that Strange's 'refraction-corrected' uplift has approximately the same form as that of Castle, with half the observed amplitude; the difference is one of degree only. In fact the refraction correction of Strange usually amounts to less than 5 cm, and about one half of the Southern California routes do not change more than the random error. Stein showed that there are seven ways to get to Palmdale from Tidal 8 in San Pedro, and they all give very consistent results: no uplift between 1926 and the late 1950's, 20 cm by the early 60's, and an additional 15 cm by the early 70's. Since the routes traversed different terrain under different temperature and procedural conditions, Stein felt that this could not be coincidental.

Stein argued that the NGS refraction correction takes the assumed ambient temperature as a function of time of year and location to approximate what is presumed to be stable nonlinear vertical temperature gradient. If the gradient is very unstable, or if it is stable but linear with height, no differential refraction would accumulate. A wind velocity gradient of only 3 m/s (its 4 m · s⁻¹ mean speed) would reduce the temperature gradient by 50% for Southern California conditions. Stein asserted that the behavior of refraction as a function of wind speed and ground thermal properties (e.g., frost, asphalt, railroad gravel) was unknown. Stein proposed that the USGS run a field experiment between Saugus and Palmdale this spring and solicited the help and expertise of the NGS for its operation. He also recommended that Strange test the NGS refraction correction on the 20 leveled circuits of the 1978 NGS Southern California Releveling Program to see if the correction significantly reduces the misclosures. Stein closed by showing a 50 km long San Gabriel Mountain leveling route that displays 13 cm of uplift during 1979–80. The same standards and procedures were used for both surveys. No more than 2 cm of this can be explained by rod or refraction corrections, which indicates that a mobile crust exists in Southern California and that this mobility is not confined to the 1960's.

During the discussion period which followed the presentation, it became apparent that all three had used much the same data but had come to markedly different conclusions. There was a question about whether movement of station Woody, in the Sierra Nevada, relative to Lebec, of some 209 mm was real and whether it represented movement at Lebec or at Woody. Another interesting point brought up by Jackson was that prior to 1964, the graduated marks on the rods were painted on after the calibration procedure was performed. Thus in these data there is some question about the validity of the calibration procedure. Stein pointed out however, that even with this uncertainty, the various data from different lines are still relatively self-consistent.

Jackson and Strange both commented that there was little redundancy in the earlier surveys (before the 1962 uplift). A further question concerned the likelihood that errors such as rod miscalibration and refraction would produce errors as consistent in space and time as the hypothetical bulge. Stein considered this unlikely. Strange suggested that the change in average sight length in the mid 60's could explain the temporal consistency. Jackson doubted the claimed temporal and spatial consistency of the uplift, but pointed out the change in calibration procedure in 1964, just in case.

A question from the floor concerned the reliability of leveling data on nearly level profiles. Stein and Strange suggested that they should be reliable. Jackson said that current models for refraction predicted negligible errors for slopes less than 1%, but that our understanding of refraction is not adequate to be sure of this. Rod miscalibration may be severe on mild slopes if successive readings repeatedly span a small kink in a rod.

Jackson also stated that when height-correlated errors exist over regions of uniform slope, the apparent tilts are also uniform and cannot be distinguished from uniform tectonic tilting. Thus variations in slope are required if systematic errors and tectonic tilting are to be distinguished. Unfortunately, many of the lines run along slopes, such as railroad track beds, that are nearly uniform for practical reasons.

The afternoon session began with a discussion by W. Thatcher (USGS), of a similar aseismic uplift on Izu peninsula in Japan from 1974-present. The uplift has a maximum amplitude of about 20 cm, is in an area noted for compressional tectonics, and is confirmed by gravity data whose maximum amplitude was ~40 μGal. Many of the lines which define the uplift run along the coast so height-correlated errors are not a problem. Additionally, the Japanese data had not been corrected for possible refraction effects.

R. Reilinger (Cornell) discussed some of the Southern California leveling data in greater detail. In particular he discussed data from the Saugus basin, an area of active groundwater withdrawal. The leveling data in this area show some apparent relative subsidence. Taken together with aquifer dimensions and properties, the possibility of near-surface subsidence is reasonable. Reilinger suggested that while some Southern California releveling measurements appear to reflect tectonic deformation, others are significantly affected by systematic errors and near-surface movements. He concluded that the configuration of the 'Palmdale Bulge' will, at the very least, require revision in light of improved understanding of those factors that can influence releveling observations. Although other leveling data in the U.S. is demonstrably contaminated by height-related errors, Reilinger concludes that the Saugus basin data show real deformation.

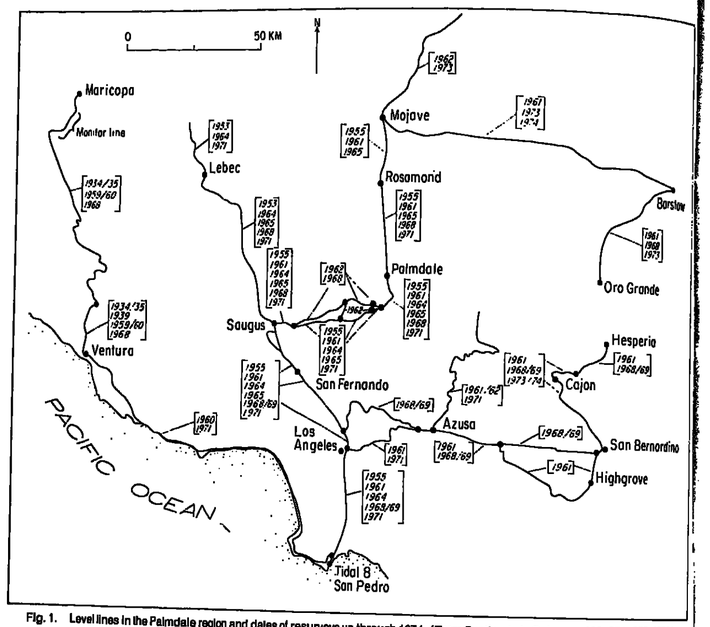

Fig. 1. Level lines in the Palmdale region and dates of resurveys up through 1974. (From Castle et al., *Science*, 192, 251–253, 1976.)

J. Whitcomb (CIRES) discussed an interesting coincidence of leveling, gravity, and VLBI data at the site of the Jet Propulsion Laboratory. Gravity at 30 sites in the Southern California area has been monitored systematically since 1974 in cooperation with the ARIES/VLBI experiment. In 1975, and again in mid-1979 it appeared that gravity showed a change of 30–50 μGals. Both leveling and VLBI showed similar patterns of deformation at the same time, with an amplitude in 1975 of about 10 cm down, and in 1977 of about 5 cm.

P. MacDoran (JPL) discussed in more detail the horizontal ARIES observations taken from 1974. These showed general coincidence both in space and time with other horizontal and vertical measurements, particularly the horizontal strain measurements of the USGS. One potentially large source of error in the ARIES technology is the effect of the ionosphere. MacDoran showed one apparent strain event that was in fact due to the influence of a large solar flare, in March 1980, on the ionosphere. When two different means of accounting for ionospheric effects are used, the results are roughly similar.

J. Savage (USGS) discussed horizontal strains that he has observed in the Southern California area since 1971. The most detailed observations temporally were taken in the vicinity of Palmdale. These show a contraction from 1971 to 1979 of about 1 μstrain total, followed by an extensional pulse of 1 μstrain. Since mid-1979, the strain has been essentially constant to within data errors, although there has been a suggestion of a slight upward concavity to the strain profile since mid-1979. Other strain observations nearer to the San Gabriel fault show some agreement with those at Palmdale, even though observations were not as frequent or at exactly the same times. If it is assumed that all deformation is occurring in Southern California, then the NASA Goddard satellite laser ranging experiment between Otay Mountain and Sacramento support Savage's data as well.

D. Agnew (CIRES) discussed the statistical problems involved in attempting to extrapolate crustal strain data to geologic times. Using the spectral density function for a self-similar process to represent the strain time series, f^{β}, where f is frequency, he showed that a value of β between −2 and −3 is consistent with the observed diminishing rate of deformation as the averaging time is increased.

B. Leitner (Caltech) described seismicity data in Southern California that was observed along the San Andreas fault from Lake Hughes to Juniper Hills. Since about November 1976, a relatively intense burst of activity has occurred at both Lake Hughes and Juniper Hills. As time has progressed, the activity has gotten somewhat more diffuse spatially. Most interestingly, a striking quiescence has occurred from Lebec southeast to Palmdale and from Cajon southeast. The onset of quiescence coincided within several months with the extensional strain event observed by Savage. Other data show coincident temporal anomalies, including well water level, Raydon, Whitcomb's gravity, and MacDoran's VLBI.

The session ended on a somewhat ambiguous note because no clear consensus emerged on the part of either the principal speakers or the audience. It appeared that the most intense discussion was over the reality of the pre-1965 data, which would seem to call into question only a part of the total deformation. From the afternoon session, there seemed to be some basis for believing that some activity was occurring in the Transverse Ranges during the mid to late 70's, but exactly what was left unclear. Each of the three principals was firmly committed to his point of view, and each gave convincing arguments. The participants were left with the general feeling that only more analysis, verification experiments, and observations would resolve the issue of whether or not the uplift is indeed real.

Marcia McNutt was born and raised in Minnesota. She received a B.A. in physics from Colorado College in Colorado Springs in 1973 and a Ph.D. in earth sciences from Scripps Institution of Oceanography in 1978. After teaching for a year in the Department of Geology and Geophysics at the University of Minnesota, Marcia joined the Office of Earthquake Studies of the United States Geological Survey in Menlo Park, California. She organized the Asilomar meeting of the John Muir Geophysical Society as part of her duties as the Society's current secretary. She is likely to retain her post for another year unless someone else volunteers soon.

John B. Rundle is a staff member in the Geophysics Research Division of Sandia National Laboratories in Albuquerque, New Mexico. He obtained a B.S.E. degree in aerospace engineering from Princeton University in 1972, an M.S. in geophysics from UCLA in 1973, and a Ph.D. in geophysics from UCLA in 1976. He spent a year as a postdoctoral fellow at UCLA, and since 1977 has been at Sandia National Laboratories. His research interests center mainly around modeling crustal deformation processes; using lineal-element models, but also include continuum models for mixtures of solid-solid and solid-liquid systems. He is a member of the American Geophysical Union, the American Society of Mechanical Engineers, and the Society for Natural Philosophy.

News

North Carolina State Revamps Geosciences

North Carolina State University's Department of Marine Sciences and Engineering and the Department of Geosciences have been combined to form the Department of Marine, Earth, and Atmospheric Sciences, according to university chancellor Joab L. Thomas. The new department is headed by Jay Langfelder, former head of the marine sciences and engineering department.

Langfelder said that the new department will be able to provide a stronger program for students. The marine science and engineering department has traditionally been graduate and research oriented, while undergraduate studies were emphasized in the other department, he said. 'The combination should help both programs.'

The new department offers doctoral degrees with specialties in atmospheric, earth, and marine sciences. ⊠

Application of Satellite Data to Study of Ocean Surface Energetics

A workshop on 'The Application of Existing Satellite Data to the Study of the Ocean Surface Energetics' was held November 19–21, 1980, at the University of Wisconsin-Madison. It was sponsored jointly by the Space Science and Engineering Center at University of Wisconsin-Madison and by NASA.

The major goal of the workshop was to define specific tractable problems by using the existing satellite data set. To this end the present state of research in the area of ocean surface energetics was discussed, with particular emphasis on six topics: heat fluxes at the interface, net radiative budget, currents and topography, wind and wind stress, precipitation, and sea surface temperature.

V. Suomi opened the workshop by reviewing the ongoing research activities that use satellite data. Then F. Bretherton demonstrated the importance of studying the ocean surface energetics for understanding the role of the oceans on the climate system. He also briefly discussed the accuracy needed for quantitative measurements to be useful for model validation. These review presentations were followed by more technical presentations by the participants during the first day and a half. In the remaining time, discussions were held both in working groups and with the entire group. Reports of the summary and conclusions of each working group, and of all the presentations, are included in the proceedings of the workshop. These proceedings are available from the University of Wisconsin Press.

It is expected that what was accomplished in the workshop will serve as an impetus for further discussion and collaboration among the scientists involved in the remote sensing of the oceans. Subsequent workshops are sure to serve as forums for the growing interest of the science community in this expanding area. These are certain to demonstrate, even more conclusively, the scientific effectiveness of remote sensing tools in the study of oceanographic problems.

This news item was prepared by Catherine Gautier, workshop coordinator, Space Science and Engineering Center, University of Wisconsin-Madison. ⊠

Geophysicists

W. W. Hutchison, past secretary general of the International Union of Geological Sciences and scientific editor of *Episodes*, has been appointed director general of the Geological Survey of Canada. He replaces *D. J. McLaren*. Hutchison received this year's Bancroft Medal of the Royal Society of Canada.

Janardan G. Negi, area chairman of theoretical geophysics at the National Geophysical Research Institute in Hyderabad, India, and *B. K. Sahu*, of the Indian Institute of Technology in Bombay, have been awarded the 1980 Shanti Swarup Bhatnagar Award in earth sciences. The prize is the highest award for scientists in India.

New Publications

Proceedings of the Second International Symposium on Problems Related to the Redefinition of North American Vertical Geodetic Networks

G. Lachapelle, Canadian Institute of Surveying, Ottawa, Canada, 978 pp., 1980, $25.00 (Canadian).

Reviewed by Ervin Groten

Less than 4 months after the closing session, the proceedings of the Second International Symposium on Problems Related to the Redefinition of North American Vertical Geodetic Networks, held in Ottawa, Canada, May 26–30, 1980, have been published in an impressive volume of 978 pages. This is the way proceedings should be published.

All the more so since the symposium was held at a time when large-scale leveling was being discussed, criticized, and to some extent, called into question. For more than a century, geodetic leveling was generally considered one of the most reliable and accurate measuring techniques in geodesy. Large-scale repeated levelings were used in order to evaluate uplift and subsidence rates over continental distances. This was often done without detailed, if any, consideration of possible distortions in large networks. Recent discrepancies between oceanic and geodetic leveling results finally led to a new discussion and reconsideration of possible distortion in first-order systems. The combination of terrestrial nets with satellite results, and the associated problem of precise definition of vertical datums, is a further complication which is closely connected with the determination of the 'offsets' of national datums with respect to the geoid and mean sea level. The precise definition in terms of operational geodesy is another unsolved problem.

The symposium organizing committee has succeeded in presenting a volume of 62 concise but profound papers that cover the whole spectrum of complex questions and associated technical problems and solutions. The scope of the meeting went far beyond the specific definition of the North American Vertical Datum and its implementation.

T. J. Kukkamaki's refreshing keynote address at the beginning of the meeting is an elementary but extremely competent and concise description of the present situation in precise leveling. It is followed by the status reports, presented by C. T. Whalen (U.S.), R. Sosa Torres (Mexico), H. Skaggs, (describing the status of work done by DMAHTC in Mexico and Central America) and G. Lachapelle and R. Gareau (Canada). The extent of the work being done at the agencies becomes obvious when we imagine that in the U.S. alone a total of more than 10^8 km of first- and second-order leveling has to be processed; the report gives a clear, although concise, presentation of the scientific and management efforts involved in the new vertical datum definition. The tentative 11-year plan in the paper by Lachapelle and Gareau illustrates the situation in a straightforward way.

R. H. Rapp and O. L. Colombo deal in a profound manner with the reference system problem; Rapp concentrating on the basic questions and Colombo treating the topic more in terms of operational geodesy. Rapp clearly points out the present problems inherent in terrestrial and satellite data combinations. Even though his 'easy definition' of the geoid is not unique, he elucidates the variety of possible solutions; Colombo discusses a specific operational solution that leads to an accuracy of about ± 0.3 m. These global considerations are supplemented by the paper of S. O. Wigen and F. E. Stephenson who compare secular trends at individual tide gages with those analyzed for station pairs along the Canadian West Coast. Their numerical results are impressive. W. D. Forrester's detailed explanation of steric and geostrophic leveling methods is of great value for interpretations of repeated leveling and associated comparison with geodetic results. W. R. Peltier summarizes his recent results; unfortunately, the reader who is interested in large-scale gravity field phenomena, deglaciation, etc., is referred to forthcoming papers. Peltier's paper, as well as the following paper by D. R. Larden, makes it clear to what extent the geoid is of geophysical interest, even though in modern geodesy the geoid, as a reference surface for orthometric heights, may no longer fulfill the requirements of millimeter accuracy. Variations of the geocenter and of the geoid in space are studied in view of various long-period mass transfers, such as geotectonic plate motion, groundwater and atmospheric pressure variations, etc. J. M. Zarzycki, as well as R. Moreau and G. Laflamme, discuss interesting engineering aspects of various height-determination procedures and their combination with other techniques. In R. J. Mitchell's presentation the treatment of the tidal observation bias supplements, beside other useful contributions, the tide gage discussions mentioned earlier. In addition to Peltier's long-term viscoelastic considerations, I. A. Maslow and A. E. Molchanov discuss short-term elastic strain-stress questions (abstract only).

M. Kumar and T. Soler (abstract only) reconsider leveling results in Southern California. Various unexplained uncertainties (beside possible leveling refraction anomalies) in leveling data lead them to the conclusion that still unexplained leveling distortions exist; the 'sea slope' problem is supposed to deserve yet further investigation. R. M. Berry and G. Godin treat the consequences that arise from the nonparallelism of level surfaces and deviations of the sea surface from equilibrium, respectively. D. Nagy and J. G. Tanner study vertical datum offsets, time dependence, and associated phenomena, with respect to gravity anomaly computations. In view of the nonstationarity of geodetic datums, R. O. Castle and P. Vanicek discuss alternatives to the 1929 vertical datum that are based on geodetic and geological principles. The appropriate definition, implementation, and continuous monitoring of the 'zero-height-offset' is one of the basic problems of modern high-precision geodesy that cannot be solved by terrestrial measurements alone. J. Kakkuri, together with M. Kostiainen and M. Takalo, presents a total of four papers that deal with various remarkable Finnish contributions to high-precision repeated leveling and gravity observations. A. J. Anderson gives his explanation of variations in high-precision gravity measurements in Fennoscandia. J. Adams and R. Reilinger present a partial explanation of the rate differences that arise in the comparison of repeated leveling results with geological data that is mainly related to seismically active areas; E. Kanngiesser discusses geodetic results obtained in active volcanic areas of Northern Iceland, whereas P. Gagnon et al. present special leveling techniques developed in view of crustal movement studies. Finally, S. Mira and J. Reis consider the national net and the control nets in Indonesia, respectively.

A series of interesting papers on net adjustment is given in session 4. A useful minimization of the sum of absolute residuals in terms of a simplex method is proposed by P. Meissl, in view of relatively small sensitivity to outliers. Design problems are discussed by Th. Leonnard and W. Niemeier, as well as by P. A. Cross and B. M. Whiting. Statistical aspects are treated by A. J. Pope (abstract only), E. G. Anderson and J. A. R. Blais (abstract only) and D. G. Milbert; J. J. Kok et al describe the 1979 adjustment of the EULN European net and its analysis.

C. C. Tscherning compares collocation data with results obtained from other methods for the prediction of gravity anomalies; he basically corroborates Ramsayer's well-established and well-known values for gravity spacing. Other gravity aspects are brought up by P. Vanicek and F. A. Kassim; C. C. Goad proves that, for the component M_2, tidal loading can be sufficiently modeled by using Schwiderski's sea tide model. G. Hein investigated groundwater effects on repeated leveling results.

Refraction problems in the U.S. are carefully investigated by S. Holdahl; these results, as well as a study on the use of leveling results for dual purposes, are presented in session 5 of the meeting. O. Remmer proposes a modification of Kukkamaki's refraction formula. P. V. Angus-Leppan and F. Brunner discuss additional aspects of refraction. Finally, C. T. Whalen presents an interesting comparison of various refraction models in a test field.

W. E. Strange concludes that various systematic errors can lead to totally incorrect geotectonic conclusions, whereas E. Grafarend studies a time-varying leveling net associated with a nonconservative gravity field. He thus bridges the conceptual gap between dynamic (i.e., oceanic) and geodetic leveling.

Technical aspects (calibration, modification of instruments, hydrostatic leveling, the very important aspects of motorized leveling) are presented by W. D. Forrester, A. Urban, H. Schlemmer, E. I. Balasz, M. Takalo, J. M. Becker, B. U. Witte, S. Vamosi, and L. A. Kivioja.

The last session is ended by a comparison of various height determination procedures, including inertial techniques (C. R. Penton). A comparison that deals especially with modern techniques is given by A. Hittel and J. Hagglund, whereas J. F. Feller et al. discuss their highly portable absolute gravimeter which yields accuracy of a few microGals in less than 1 hour.

Finally, the volume contains summaries of the open meetings of IAG Special Study Groups 1.42 and 1.53, as well as a list of participants.

The meeting brought together experts from all over the world, and on the whole the proceedings fully represent the present state of the art in precise leveling.

This volume contains an extremely valuable compendium of scientific papers; at the same time it provides much user-oriented material. Everybody involved in geodynamics, modern geodesy, and datum problems will surely appreciate the quick and competent compilation of this volume. Perhaps some might wonder whether the discussions should have been incorporated; it seems that faster publication was more important.

Reference

Lachapelle, G., Second international symposium on problems related to the redefinition of North American vertical geodetic networks, *Eos Trans. AGU*, *61*(39), 646, 1980.

Ervin Groten is with the National Geodetic Survey, NOS/NOAA, Rockville, Maryland.

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POSITIONS AVAILABLE

Exploration Geophysicist/University of Oklahoma. The School of Geology and Geophysics at the University of Oklahoma will have an experienced exploration geophysicist to fill the Frank and Betty Schultz Professorship, and is seeking nominations and applications for the position. The person must be a distinguished scientist who has made important contributions to exploration geophysics through research. Preference will be given to a scientist whose specialty is seismic properties of earth materials and who has earned the Ph.D. The Schultz Professor will provide leadership and guidance in establishing a quality teaching and research exploration geophysics group. The University of Oklahoma has recently made a strong commitment to the earth sciences with the establishment of a College of Geosciences, to be housed in a new building. The School of Geology and Geophysics will expand from its present faculty of 16 to 26 faculty members by 1986. This will include three scientists in the exploration geophysics area, five in structure-tectonophysics-solid earth geophysics and others in stratigraphy-paleontology, geochemistry-petrology, and energy resources.

Applications are due April 30, 1981. Inquiries, nominations, and applications should be sent to John Wickham, Director, School of Geology and Geophysics, University of Oklahoma, Norman, OK 73019.

The University of Oklahoma is an equal opportunity employer.

Solid Planet Geophysicist/Texas A&M University. The Department of Geophysics at Texas A&M University is pleased to announce availability of a junior level, tenure track faculty position. The department emphasizes solid earth geophysics with concentrations in tectonophysics, geodynamics and internal structure. We are seeking a talented and active researcher and teacher who will complement, strengthen, and broaden current areas of expertise. There are excellent opportunities for interaction and collaboration with members of our department as well as those in the departments of oceanography and geology and in the center for tectonophysics. Qualified scientists are requested to send resumes to Neville L. Carter, Head, Department of Geophysics, Texas A&M University, College Station, TX 77843.

Texas A&M University is an equal opportunity employer.

The Hebrew University of Jerusalem, Structural Geologist, Geophysicist. Applications are invited for a tenure track position in structural geology and/or geophysics, to be filled at the senior lecturer or associate professor level, effective October 1981.

The appointee is expected to develop a strong research program and to offer courses in his own field of research and related subjects at graduate and undergraduate levels (including introductory and field courses) as well as to advise M.Sc. and Ph.D. students. The department carries out a vigorous research program and cooperation with other staff members is both possible and desirable.

Appicants should forward a curriculum vitae, list of publications and two letters of recommendation to The Chairman, Department of Geology, Institute of Earth Sciences, The Hebrew University of Jerusalem, Israel.

Assistant Professor in Atmospheric Science-climate dynamics.

Qualifications: Ph.D. in atmospheric science or related field with strong background and evidence of experience in the theory, phenomenology, and numerical modeling of atmospheric motion systems and a demonstrated interest in the study of climate and its physical basis.

Teaching responsibilities include: numerical prediction course and sharing in teaching of one or two other undergraduate courses in basic and applied theory and phenomenology and one graduate level course.

Research focus is on climate, its energetics and dynamics. These studies would complement existing projects involving hydrologic cycles, regional evapotranspiration, trace gas transport and air pollution effects.

Applicants should submit resume, transcripts, copies of publications, and the names and addresses of at least three references to: Dr. Bryan Weare, Search Committee, Department of Land, Air and Water Resources, University of California, Davis, CA 95616, by May 15, 1981.

The University of California is an equal opportunity/affirmative action employer and invites applications from all qualified individuals.

Research Fellow Aqueous Solution Geochemistry. The Australian National University invites applications for appointment to the position of research fellow—aqueous solution geochemistry, in the Research School of Earth Sciences from those holding a Ph.D. degree in a relevant field.

The Research School of Earth Sciences has recently established an interdisciplinary research group in environmental geochemistry. Current areas of research include application of stable isotope studies and radiochemistry, to the geochemical evolution of the Great Barrier Reef, the Gulf of Carpentaria and the geochemical record contained in the sediments of australian inland lakes. Special attention is also being devoted to holocene palaeoclimatology and the carbon cycle. This group wishes to appoint a research fellow specializing in aqueous solution geochemistry to work on a collaborative basis on research projects in the above areas.

In addition to participating in collaborative research programs, the appointee will have the opportunity of pursuing independent research in general areas of interest to the group. The geochemical environment of australian inland lakes and groundwaters is of particular interest and the appointee should be prepared to participate in a major research program aimed at understanding the solution, transport and precipitation of chemical species in heterogeneous aqueous solutions and sediments. A wide range of evaporate minerals are known to occur in these basins at the present time.

Consequently, the research undertaken by the successful applicant may have implications not only to environmental geochemistry and palaeoclimatology but also to economically significant topics such as the mobilization, fixation and migration of metals and other elements of economic significance.

Applicants should have broad interests in geochemistry, together with a strong background in theoretical solution geochemistry and relevant experimental-chemical techniques. In addition to describing their qualifications, applicants are invited to submit research proposals detailing the general research directions and specific projects which they would wish to pursue. Further information concerning the position can be obtained directly from Dr. W. Compston.

Salary on appointment will be in accordance with qualifications and experience within the range: Research fellow $19,132–$24,972 per annum. Appointment will be for 2 or 3 years in the first instance with the possibility of extension to five years. Superannuation, housing assistance, reasonable appointment costs.

The University reserves the right not to make an appointment or to make an appointment by invitation at any time. No fixed closing date is specified for the above position.

Interested candidates are requested to submit their applications to The Registrar, Australian National University, PO Box 4, Canberra, ACT 2600, Australia.

Assistant Professor, Hydrology/Water Resources. Tenure track appointment involving teaching and research in hydrology and water resources. Excellent opportunities for interdisciplinary collaboration with ecologists, meteorologists, geologists and hydrologists. Please call or send resume, reprints, and names of three references to George M. Hornberger, Department of Environmental Sciences, Clark Hall, University of Virginia, Charlottesville, Virginia 22903.

Closing date for applications April 15, 1981.

The University of Virginia is an Equal Opportunity/Affirmative Action Employer.

Geophysicist/Structural Geologist, Albion College. A tenure track position, commencing Fall 1981, is open at the assistant professor level at Albion College's Department of Geological Sciences. The position involves teaching undergraduate laboratory courses in structural geology and geophysics and introductory lab courses or non-lab courses in geology. The Department is developing a geophysics geology major and has some geophysical equipment. Candidates with a Ph.D. or who are about to acquire a Ph.D. are preferred.

Depending upon the applicant's background, the new staff member may have the opportunity to assist in teaching at Albion's geology field camp for additional remuneration. A 6-week summer field methods course is offered to students from many colleges and universities at the field camp located in the Front Range near Boulder, Colorado.

Albion College is a co-educational liberal arts college located in southern Michigan, an hour's drive from Michigan State University, The University of Michigan and Western Michigan University. The Department has four staff members and 30 to 40 majors; it is a well-equipped department occupying a floor-and-a-half of a new science center.

Resume, transcripts and three letters of reference should be submitted to: Prof. Lawrence D. Taylor, Department of Geological Sciences, Albion College, Albion, Michigan 49224.

Albion College is an equal opportunity employer.

Structural Geologist. The Department of Geosciences at Purdue University invites application for a tenure track faculty position in structural geology, starting in August 1981. Rank and salary will be commensurate with qualifications. A Ph.D. is required. The individual will be expected to teach undergraduate and graduate courses in structural geology and tectonics, participate in summer field courses, and pursue an active research program. Preference will be given to a candidate with an applied field orientation and a strong background in the quantitative analysis of field data. The department has active programs in petrology, geophysics, and engineering geology and has a close working relationship with the geotechnical group in civil engineering and the Laboratory for Applications of Remote Sensing. Closing date for application is April 1, 1981. Applicants should send a resume, the names, addresses, and telephone numbers of three referees, and a brief statement of research interests to R. H. McCallister, Department of Geosciences, Purdue University, West Lafayette, IN 47907.

Purdue University is an equal opportunity/affirmative action employer.

Seismologist. The Department of Geology at the University of Illinois, Urbana-Champaign, has an opening for a tenure track position at the assistant professor level, beginning during the 1981–82 academic year. A Ph.D. is required. The applicant should have a strong background in geology, and post-doctorate experience is desirable. Candidates with interests and experience in tectonic studies based on seismological observations will be given preference. The successful candidate is expected to develop an active research program to complement existing programs in geodynamics, solid earth geophysics, and rock physics. There is also opportunity for interaction with programs in the Departments of Theoretical & Applied Mechanics and Civil Engineering, and the Interdisciplinary Materials Research Laboratory. Send resumé and names of three references to: Dr. John Hower, Head, Department of Geology, University of Illinois, 245 Natural History Bldg., 1301 W. Green St., Urbana, IL 61801 (Telephone: 217/333-3540). Applications should be received by April 15, 1981.

The University of Illinois is an affirmative action/equal opportunity employer.

Faculty Position: University of Iowa. The Department of Physics and Astronomy anticipates one or two openings for tenure track faculty in August 1981. Research specialties for which substantial resources are available are magnetospheric and auroral physics and space and laboratory plasma physics, both theoretical and experimental. Other specialties of interest are astronomy, astrophysics, elementary particle physics, atomic physics, condensed matter, and low energy nuclear physics. The positions involve undergraduate and graduate teaching, guidance of research students, and personal research. Interested persons should send a résumé, a statement of research interests, and the names of three professional references to Search Committee, Department of Physics and Astronomy, University of Iowa, Iowa City, IA 52242.

The University of Iowa is an equal opportunity/affirmative action employer.

Economic Geologist. The Department of Geoscience at New Mexico Institute of Mining & Technology wishes to add staff members in the field or ore deposits and/or energy resources, petrology, structural geology and geomorphology remote sensing. Applications with expertise in any of these fields will be considered but preference will be given to those with proven capabilities in economic geology. If successful, candidates will be expected to develop an active research program in addition to participating in instruction. Rank open, depending on qualifications and experience. A Ph.D. is required. Applied or exploration geophysics orientation are preferable; however, other specializations in geophysics also will be considered.

Primary responsibilities will include generating and conducting research programs as well as teaching graduate courses in geophysics. The department currently consists of 31 regular faculty members including 18 in the areas of geology and geophysics. Please send resume and names of three references to Prof. I. J. Won, Search Committee Chairman, Department of Marine, Earth and Atmospheric Sciences, North Carolina State University, Raleigh, NC 27650, USA. We hope to make a final decision prior to May 31, 1981.

North Carolina State University is an equal opportunity/affirmative action employer.

Sedimentary Geologist/Micropaleontologist, Washington University. The Department of Earth and Planetary Sciences, Washington University, has available a tenure track, assistant professorship position, beginning in the 1981–82 academic year for a geoscientist with research interests in diagenesis of sediments or in micropaleontology.

The successful candidate must have the following attributes: demonstrated creativity and promise of excellence in research and teaching; intent to develop a vigorous graduate research program; desire to teach courses in field of interest and related fields of geoscience at undergraduate and graduate levels.

Send resume, statement of future research interests, and names of at least three references, to Larry Haskin, Chairman, Department of Earth & Planetary Sciences, Washington University, St. Louis, MO 63130. Applications received through April 15, 1981.

Washington University is an equal opportunity/affirmative action employer.

Geophysicist North Carolina State University—Raleigh. The Department of Marine, Earth and Atmospheric Sciences invites applications for a presently available tenure track position in geophysics. Rank and salary are open, depending on qualifications and experience. A Ph.D. is required. Applied or exploration geophysics orientation are preferable; however, other specializations in geophysics also will be considered.

Primary responsibilities will include generating and conducting research programs as well as teaching graduate courses in geophysics. The department currently consists of 31 regular faculty members including 18 in the areas of geology and geophysics. Please send resume and names of three references to Prof. I. J. Won, Search Committee Chairman, Department of Marine, Earth and Atmospheric Sciences, North Carolina State University, Raleigh, NC 27650, USA. We hope to make a final decision prior to May 31, 1981.

North Carolina State University is an equal opportunity/affirmative action employer.

Geochemistry/Brittle Deformation, University of New Brunswick. The Department of Geology has a tenure track position available from July 1, 1981 at assistant professor or higher level. The successful applicant will be expected to teach both undergraduates and graduates as well as carrying out research and supervising graduate students.

Applications will be accepted in the following fields: geochemistry of ore bodies, exploration, environmental or soil geochemistry, brittle deformation, rock mechanics or site engineering.

Applicants should have a Ph.D. and preferably, post doctoral experience. Applications including a curriculum vitae and names of three referees should be sent to P. F. Williams, Chairman, Department of Geology, University of New Brunswick, Fredericton, N.B. E3B 5A3.

Battelle, Pacific Northwest Laboratories. Applications are invited for a postdoctoral position in geophysics with emphasis on middle or upper atmospheric research at the Battelle Observatory in Richland, Washington. Stipend will be $18,000 initially; the position offers the possibility of a permanent research position at the end of the postdoctoral appointment. Address inquiries to R. A. Stokes, Battelle Observatory, Battelle, Pacific Northwest Laboratories, P.O. Box 999, Richland, WA 99352.

Northern Arizona University. Tenure track position in the department of physics. Presently planning early implementation of a masters degree program in atmospheric science. Candidate expected to contribute to research program. Teaching may be in undergraduate physics program as well as atmospheric science. Assistant or associate professor level. W. R. Willis, Box 6010, Northern Arizona University, Flagstaff, AZ 86011.

Faculty Position in Physical Oceanography. The Department of Marine, Earth and Atmospheric Sciences at North Carolina State University invites applications for a nine-month, hard money, tenure track position at the assistant or associate professor level for a physical oceanographer, specializing in the numerical modeling of oceanic flows.

Applicants should have a strong background in geophysical fluid mechanics and the abilities to develop a funded research program and graduate level courses. Presently funded areas at NCSU include estuarine, coastal and deep-water oceanography.

Send curriculum vitae and the names of three references by March 31, 1981 to Professor G. S. Janowitz, Chairman, Search Committee in Physical Oceanography, Department of Marine, Earth and Atmospheric Sciences, North Carolina State University, P.O. Box 5068, Raleigh, NC 27650.

North Carolina State University is an equal opportunity/affirmative action employer.

Sediment Transport/Geological Oceanography, North Carolina State University. A tenure track position is available in the Department of Marine, Earth and Atmospheric Sciences at the level of assistant or associate professor. Applicants should have a thorough understanding of sediment transport, and a general background in geological oceanography. A Ph.D. is required. The candidate will be expected to strengthen the graduate teaching and research programs. The applicant's research interests can be theoretical, experimental, or observational, but must involve quantitative examination of marine sediment transport. Applicants should forward a resume, including a list of courses taken/taught, and the names of at least three references to Dr. Charles A. Nittrouer, Chairman, Search Committee, P.O. Box 5068, NC State University, Raleigh, NC, 27650. Application materials should be sent by March 31, 1981.

North Carolina State University is an equal opportunity/affirmative action employer.

Faculty Appointment/Colorado State University. The Department of Earth Resources, Colorado State University invites applications for a tenure track appointment with emphasis on active research experience in remote sensing, and an interest in teaching graduate and undergraduate students beginning September 1981. The candidate is expected to have a Ph.D. degree in geology, watershed sciences or in a related field and is expected to develop and maintain a vigorous research program with special emphasis on the application of state-of-the-art remote sensing techniques to the investigation of natural resource phenomena. The candidate is expected to teach undergraduate and graduate courses in the application of remote sensing to natural resources.

Rank and salary are open and dependent on experience and qualifications of the applicant.

Applicants are invited to submit curriculum vitae, three letters of reference and a letter describing research and teaching interests to Dr. R. B. Boyne, Department of Earth Resources, Colorado State University, Fort Collins, Colorado 80523/(303) 491-6298.

Deadline for receipt of applications is April 15, 1981.

CSU is an EOE/AA. E.O. Office: 314 Student Serv. Bldg.

Faculty Position/Synoptic Meteorology. The University of Maryland invites applications from qualified scientists for a tenure track faculty position at the assistant or associate professor level, commencing fall 1981. Candidates must have a Ph.D. in meteorology or related areas and have an area of specialization in synoptic and dynamic meteorology. Teaching experience is desirable. The successful candidate will be expected to teach primarily graduate level courses in synoptic meteorology and carry on an active research program. Salary will be commensurate with qualifications and experience.

All applicants should send curriculum vitae, a brief statement of research interests and names, addresses and telephone numbers of three professional references to: Professor Ferdinand Baer, Chairman, Department of Meteorology, University of Maryland, College Park, Maryland 20742. Closing date for applications is April 15, 1981.

The University of Maryland is an equal opportunity/affirmative action employer.

Director Meteorology Division, Air Force Geophysics Laboratory. Air Force Geophysics Laboratory invites applications for the position of Director of the Meteorology Division located at Hanscom Air Force Base, Massachusetts. The Division is responsible for Air Force research and development in meteorology, atmospheric physics, remote and direct sensing technology, climatology, and related technologies. The division director provides external direction to an R&D program which employs over 80 people and covers a broad range of in-house and contractual scientific investigation. A candidate should have a record of distinguished achievement in meteorology/atmospheric physics as a research scientist and manager of a substantial R&D unit. This position is Air Force Senior Executive Service with a salary range of $62,247 to $57,673, subject to current $50,112 ceiling. For an application package, call collect: Robert Ellerin, (617) 861-2898. To be considered, applications must be returned by 30 April 1981.

Equal employment opportunity employer.

Senior Hydrogeologist. Fred C. Hart Associates, an environmental consulting firm, is providing technical assistance to the U.S. Environmental Protection Agency in their efforts to discover and identify hazardous waste sites, evaluate their impacts and design site clean-up measures.

An opening exists for the position of senior hydrogeologist in our Newark, N.J. office. The successful candidate will have field and management experience in groundwater contamination and will be responsible for developing monitoring programs and alternative solutions to contamination problems.

Candidates should possess an M.S. degree with five years field experience in hydrogeology, or B.S. degree and seven years field experience in groundwater contamination studies. Please forward resume to: Fred C. Hart Associates, Inc. 155 Washington Street, Newark, N.J. 07102, Att: Amelia J. Janisz.

Chemical Oceanographer. Research associate, M.S., marine organic geochemistry and its relation to ocean productivity. Cooperative Institute of Marine and Atmospheric Sciences, University of Miami and National Oceanic and Atmospheric Administration, contact Chairman Search Committee, D. K. Atwood, NOAA/AOML, 15 Rickenbacker Causeway, Miami, FL 33149.

Von Braun Post-Doctoral Fellowship in Space Physics/University of Alabama in Huntsville. Appointment effective September 1981 in a tenure track assistant professorship with reduced teaching load during the first two years. Research specialty in astrophysics, planetary science or solar terrestrial physics. Research support available from UAH, NASA and Redstone Arsenal. Salary competitive. Recent Ph.D.'s are invited to send resume, research plans and names of four references. Apply to Von Braun Fellowship Committee, Office of Academic Affairs, University of Alabama in Huntsville, AL 35899.

Equal opportunity in education and employment.

Research Associate. Position available July 1 for new Ph.D. scientist in climatology-glaciology. Work involves research in ice-climate synoptic interactions based on analysis of satellite imagery and digital data (Nimbus and DMSP systems) of climatological and cryospheric parameters using multivariate statistical techniques. Research is performed in a cooperative university/government laboratory employing scientists engaged in interdisciplinary work related to the environment.

Position requires experience in analysis and display of remote sensing data and in data processing; demonstrated ability to write scientific reports; background of glaciological-meteorological field research in polar areas; experience in interpretation of snow cover, sea ice, and cloud conditions from visible, IR, and ESMR microwave imagery and digital data; experience with multivariate statistical analysis techniques, especially as applied to meteorological or related data; experience in FORTRAN programming in a CDC Kronos or NOS operating environment; and research experience in synoptic climatology and ice-climate interactions.

Salary approximately $17,000/year. Applications including vitae and three references should be addressed to Dr. R. G. Barry, CIRES, Campus Box 449, University of Colorado, Boulder, CO 80309.

The University of Colorado is an equal opportunity/affirmative action employer.

Lunar Curatorial Laboratory: Manager. Northrop Services, Inc. has operated and maintained the NASA Lunar Curatorial Laboratory at the Johnson Space Center, Houston, Texas since its inception. We are now searching for a manager candidate with a Ph.D. in geology or geochemistry, evidence of administrative skills and a record of publication in the study of lunar samples and/or meteorite investigations. Position involves the supervision of 38 technical, scientific and clerical employees. Interested persons should send resume, including publications and references to W. S. Kurz, Manager of Personnel Services, Northrop Services, Inc., P.O. Box 34416, Houston, TX 77034.

NSI is an equal opportunity/affirmative action employer.

COURSES

Flood, Predictions, and Forecasting. June 29 to July 3, 1981. The objective is to present various methods for floods by well known lecturers. Physical understanding will be emphasized. Lecture notes are specifically written for this course. Contact H. W. Shen, Course Director, ERC, Colorado State University, Fort Collins, CO 80523, USA. Telephone (303) 491-8552; TWX 910-930-9000 ENGR CSU FTCN.

SERVICES

Pick Hammer. Two or more orders for $18.00 per hammer includes your lettering in 2-inch characters branded in the leather handle and sheath ($20.00 for one hammer + sheath). Write or call for order form: Western Heritage, 101 S. Washington St., Hinsdale, IL 60521. Telephone (312) 964-5228.

Meetings

One Year After Mount St. Helens

A call for papers has been issued for a symposium on the physical and social impacts of the Mount St. Helens eruptions. Technical sessions will be held on May 18, 1 year after the first major blast. A preliminary program is scheduled for May 17. The symposium, to be held at the Eastern Washington University in Cheney, Washington, may be continued through May 19, depending on response to the announcement.

Technical sessions will be split into those covering physical science and environment and those on the psychological, social, and economic aspects of the eruption. Included will be discussions of agriculture and soils, hydrology and water quality, wildlife and insects, remote sensing, the impact on school systems and students, the economic impact, marketing of eruption souvenirs, and the federal role in disaster assistance.

Deadline for receipt of one-page abstracts is March 20. Special arrangements needed for presentation of papers should be listed on a second page. Send abstracts, inquiries, and requests for registration forms to Michael M. Folsom, Symposium Coordinator for Physical Science and the Environment, Department of Geography and Anthropology, Eastern Washington University, Cheney, WA 99004. ✪

Hotine Symposium on Geodesy

The Eighth Hotine Symposium on Mathematical Geodesy will be held September 7–9 in Como, Italy, under the auspices of the International Association of Geodesy.

Those interested in attending should immediately contact F. Sansò, Instituto di Topografia, Fotogrammetria e Geofisica, Piazza Leonardo da Vinci, 32, 20133 Milano, Italy. ✪

FUTURE AGU MEETINGS

Chapman Conferences

Spatial Variability in Hydrologic Modeling
July 21–23, 1981. Colorado State University, Fort Collins, Colorado

Generation of the Oceanic Lithosphere
April 6–10, 1981. Airlie House, Warrenton, Virginia

1981 Midwest Meeting
September 17–18, 1981. Radisson Hotel, Minneapolis, Minnesota

1981 Pacific Northwest Meeting
September 17–18, 1981. Central Washington University, Ellensburg, Washington

AGU Oceanography Section/ASLO (American Society of Limnologists and Oceanographers) Meeting
February 16–19, 1982. St. Anthony Hotel, El Tropicano Hotel, Gunter Hotel, San Antonio, Texas

Fall Meetings
December 7–11, 1981, San Francisco
December 6–10, 1982, San Francisco
December 5–9, 1983, San Francisco

Spring Meetings
May 25–29, 1981, Baltimore
May 31–June 4, 1982, Philadelphia

Chapman Conference on Spatial Variability in Hydrologic Modeling

July 21–23, 1981
Colorado State University, Fort Collins

Purpose: The conference will provide a forum where surface and groundwater hydrologists, soil scientists, and applied statisticians can discuss progress and research approaches in dealing with spatial variability of catchment surface and subsurface properties in a distributed modeling context.

Call for Papers: Published in December 16, 1980, *Eos*. Includes program topics planned. Abstract deadline: May 15, 1981.

Convenors: D. A. Woolhiser and H-J. Morel-Seytoux.

Student Travel: Some travel money will be available to students. To apply, write to AGU, giving your educational background and your advisor's name. Briefly explain the reasons you wish to attend.

For further information, call or write Member Programs Division, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D.C. 20009 (telephone: 202/462-6903).

Geodesy in Africa

The Second Symposium on Geodesy in Africa will be held at the Kenyatta Conference Centre in Nairobi, Kenya, November 9–20. The symposium is sponsored by the International Association of Geodesy, in collaboration with the IUGG Local Committee of Kenya, the IUGG Committee on Advice to Developing Countries, and the African Association of Cartography.

Theme of the symposium is 'Geodesy in Africa in the 1980's.' R. Olawole Coker, president of the Commission for Geodesy in Africa, is the convenor.

Requests to contribute reports and papers and for registration forms and general information should be directed to R. Omandi, Survey of Kenya, P.O. Box 30046, Nairobi, Kenya, or to Coker, Kenting Africa Resource Service, 53 Lawson Street, P.O. Box 1658, Lagos, Nigeria. ✪

AGU Congressional Science Fellowship

The individual selected will spend a year on the staff of a congressional committee or a House or Senate member, advising on a wide range of scientific issues as they pertain to public policy questions.

Prospective applicants should have a broad background in science, be articulate, literate, flexible, and able to work well with people from diverse professional backgrounds. Prior experience in public policy is not necessary, although such experience and/or a demonstrable interest in applying science to the solution of public problems is desirable.

The fellowship carries with it a stipend of up to $25,000 plus travel allowances.

Interested candidates should submit a letter of intent, a curriculum vitae, and three letters of recommendation to AGU. For further details, write Member Programs Division, Congressional Fellowship Program, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D.C. 20009.

Deadline: March 31, 1981.

AGU CHAPMAN CONFERENCE
Generation of the Oceanic Lithosphere

April 6–10, 1981 Airlie House, Warrenton, Virginia

Convenors: D. C. Presnall, A. L. Hales, and F. A. Frey

Sessions planned to date:
(1) Constitution of the crust and upper mantle at spreading centers
(2) Trace elements and isotopes
(3) Experimental petrology
(4) Magmatic processes versus spreading rate
(5) Magma chamber dynamics, melt migration, mantle flow
(6) Tectonics of spreading centers
(7) Hydrothermal activity, metasomatism, metamorphism

Limited space remains. For information on registration and accommodations, write to AGU, Meetings, 2000 Florida Avenue, N.W., Washington, D.C. 20009, or call Meetings, (202) 462-6903.

Acoustic Emissions and Microseismicity

A special conference on Acoustic Emission/Microseismic Activity in Geologic Structures and Materials will be held October 5–7 at The Pennsylvania State University. The conference is sponsored by the Rock Mechanics Laboratory of the university's Department of Mineral Engineering.

The conference will consider the application of acoustic emission/microseismic techniques to a range of field and laboratory problems in general geomechanics, including stability evaluation of underground gas storage reservoirs, solution-mined caverns, earth-filled dams and tunnels, strata control in coal and hard-rock mines, earthquake mechanics, and fundamental behavior of geologic materials.

For additional information, contact H. Reginald Hardy, Jr., Director, Rock Mechanics Laboratory, Room 117, Mineral Sciences Building, The Pennsylvania State University, University Park, Pennsylvania 16802. ✪

Hydrology Day in Fort Collins

The AGU Front Range Branch has issued a call for papers for its Hydrology Day, scheduled for April 23 at Colorado State University in Fort Collins.

Hydrologists and hydrology students interested in presenting a paper should send an original plus two copies of a one-page double-spaced typed sheet that lists authors names, affiliation, address, telephone number, title of paper, and a brief (roughly one-half page) abstract to H. J. Morel-Seytoux, Vice Chairman, AGU Front Range Branch, A305, Engineering Research Center, Colorado State University, Fort Collins, Colo. 80523. The meeting planners also recommend that potential contributors call Morel-Seytoux at (303) 491-8549.

Deadline for acceptance of abstracts or telephone calls is March 13. Papers missing the deadline will be scheduled for presentation but will not be included in the program.

There is no registration fee for students and AGU Front Range members. A nominal registration fee may be charged to others. Additional questions should be directed to the vice chairman.

A prize will be awarded by the Front Range Branch to the best student paper in each of three categories: undergraduate, masters, and Ph.D. candidates. ✪

New Listings

The complete Geophysical Year last appeared in the Feb. 10 *EOS*.

Boldface type indicates meetings sponsored or cosponsored by AGU.

1981

Apr. 14–15 National Water Conservation Conference—Publicly Supplied Potable Water, Denver, Colo. Sponsor, EPA. (National Water Conservation Conference, c/o Enviro Control, Inc., P.O. Box 827, Rockville, MD 20851.)

May 11–13 Annual Meeting, Canadian Geophysical Union, Calgary, Alberta, Canada. (P. J. Savage, Pan-Canadian Petroleum Ltd., P.O. Box 2850, Calgary, Alberta, Canada T2P 2S5.)

May 11–15 1981 Seminar on Tropical Cyclone Hydrology Miami, Fla. Sponsors, WMO, NOAA. (Allen F. Flanders, National Weather Service, 8060 13th St., Room 508, Silver Spring, MD 20910.)

July 21–23 **Chapman Conference on Spatial Variability in Hydrologic Modeling,** Fort Collins, Colo. (Meetings, AGU, 2000 Florida Ave., N.W., Washington, DC 20009.)

Aug. 24–29 Eighth Annual Meeting of the European Geophysical Society, Uppsala, Sweden. (C.-E. Lund, Chairman Local Organizing Committee, Institute of Solid Earth Physics, Uppsala University, Box 556, 22 Uppsala, Sweden.)

Sept. 17–18 **Midwest Meeting,** Minneapolis, Minn. (meetings, AGU, 2000 Florida Ave., N.W., Washington, DC 20009.)

Sept. 17–18 **Pacific Northwest Regional Meeting,** Ellensburg, Wash. (Bob Bentley, PNAGU, Central Washington University, P.O. Box 1000, Department of Geology, Ellensburg, WA 98920.)

Oct. 11–15 51st Annual International Meeting of the Society of Exploration Geophysicists, Los Angeles, Calif. (William L. Baker, Technical Program Chairman, Chevron Oil Field Research Co., Box 446, La Habra, CA 90631.)

Oct. 13–16 Division of Planetary Sciences of the American Astronomical Society Annual Meeting, Pittsburgh, Pa. (B. Hapke, Dept. of Geology and Planetary Sciences, 321 Old Engineering Hall, University of Pittsburgh, Pittsburgh, PA 15260.)

Oct. 14–16 Third Surveying and Mapping Conference of the Petroleum Industry, Banff, Alberta, Canada. (The Canadian Petroleum Association, (Liz Hamilton), Canadian Petroleum Association, 1500, 633 Sixth Ave. S.W., Calgary, Alberta, Canada T2P 2Y5.)

Oct. 26–30 Symposium on Quaternary Land Connection Bridges and Human Occupation of Submerged Coastlines, La Jolla, Calif. Sponsors, Quaternary Coastlines Commission of the International Union for Quaternary Research, Scientific Committee of the International Federation of Underwater Activities. (Patricia

Scripps Institution of Oceanography, A-012, La Jolla, CA 92093.)

Dec. 18–19 Annual International Meeting of the Working Group on Mediterranean Ophiolites, Florence, Italy. (Luigi Beccaluva, Istituto di Petrografia, Via Gramsci 9, 43100 Parma, Italy.)

1982

Feb. 8–12 **Third International Geodetic Symposium on Satellite Doppler Positioning,** Las Cruces, N. Mex. Sponsors, Defense Mapping Agency, National Ocean Survey, AGU. (Richard Peat, Defense Mapping Agency, Hydrographic/Topographic Center, 6500 Brooks Lane, N.W., Washington, DC 20315.)

Feb. 16–19 **AGU Oceanography Section/ASLO (American Society of Limnologists and Oceanographers) Meeting,** San Antonio, Tex. (Meetings, AGU, 2000 Florida Ave., N.W., Washington, DC 20009.)

May 24–June 4 International Solar-Terrestrial Physics Symposium, Ottawa, Ontario, Canada. (Professor Liu, University of Illinois, Urbana, IL 61801.)

May 24–June 4 24th Plenary Meeting of COSPAR Ottawa, Ontario, Canada. (Dean Kastel, Space Sciences Board, National Academy of Sciences, 2101 Constitution Ave., N.W., Washington DC 20418.)

May 31–June 4 **AGU Spring Meeting,** Philadelphia, Pa. (Meetings, AGU, 2000 Florida Ave., N.W., Washington, DC 20009.)

Aug. 15–21 Fourth International Symposium on Antarctic Earth Sciences, Ingle Farm, South Australia, Australia. Sponsors, Australian Academy of Science, Australian Academy of Technological Sciences, International Union of Geological Sciences, Scientific Committee on Antarctic Research, Geological Society of Australia, Inc., Univ. of Adelaide. (J. B. Jago, South Australian Institute of Technology, P.O. Box 1, Ingle Farm, South Australia, Australia 5098.)

Aug. 15–22 International Meeting on Generation of Major Basalt Types, Reykjavik, Iceland. Sponsors, IAVCEI, IAGC. (Basalt Meeting, c/o G. E. Sigvaldason, Nordic Volcanological Institute, 101 Reykjavik, Iceland.)

Aug. 22–28 11th International Congress on Sedimentology, Hamilton, Ontario, Canada. Sponsor, IAS. (IAS Congress 1982, Department of Geology, McMaster University, Hamilton, Ontario L8S 4M1, Canada.)

Aug. 23–27 Ninth Annual Meeting of the European Geophysical Society, Leeds, United Kingdom. (C. R. Argent, EGS Secretary, The Royal Society, 6 Carlton House Terrace, London SW1Y, 5AG, England.)

Dec. 6–10 **AGU Fall Meeting,** San Francisco, Calif. (Meetings, AGU, 2000 Florida Ave., N.W., Washington, DC 20009.)

1983

Aug. 27 Symposium Commemorating the 100th Anniversary of the Mount Krakatau Eruption, Jakarta, Indonesia. Sponsor, Indonesian Institute of Sciences. (Didin Sastrapradja, Deputy Chairman for Natural Sciences, L1P1, JL. Teuku Chik Ditiro 43, Jakarta, Indonesia.)

Dec. 5–9 **AGU Fall Meeting,** San Francisco, Calif. (Meetings, AGU, 2000 Florida Ave., N.W., Washington, DC 20009.)

GAP

Geophysical Abstracts in Press (GAP) from several selected journals are published as they are received. The abstracts are ordered numerically in accordance with a system used for annual and cumulative indexing of all AGU publications. Index terms are available upon request and are published occasionally in *EOS*.

Copies of English translations of articles from AGU's translation journals are available either in unedited form at the time of their listing in *EOS* or in final printed form when a journal is published. The charge is $2.00 per Russian page. Send orders to AGU; payment must accompany order.

Separates—individual articles from AGU journals—are available: $3.50 for the first article in an order, $1.00 for each additional article. Articles from Russian translation journals: $2.00 per printed page. Payment must accompany order.

Particles and Fields—Ionosphere

5915 Aurorae
ROCKET-BORNE MEASUREMENTS OF PARTICLE PULSATION IN PULSATING AURORA
Andrew W. Yau (Herzberg Institute of Astrophysics, National Research Council of Canada, Ottawa, Canada K1A 0R6), Brian A. Whalen and D.J. McEwen
Rocket-borne measurements are made of the particle pulsation characteristics in a pulsating aurora. A train of eleven 17-s pulsations was observed in electron intensities at energies as low as 2 keV and as high as 28 keV. During the pulsations, a factor of 2 increase in the electron intensities at the few-keV range, and a factor of 3 to 5 increase in the intensities in the 20-keV range, were measured. Time-delays in pulsations of low-energy electrons are observed; they indicate the source of particle injection to be near the equatorial plane. The electron energy spectra in pulsation maxima are characterized by higher Maxwellian temperatures than their pulsation-minima counterparts. The few-keV electrons have more trapped distributions at pulsation minima than at pulsation maxima. The energetic electrons are isotropic at all times. The altitude profiles of the electron fluxes at various energies are examined, in an attempt to identify the possible existence of thin optical pulsating ionized structures; they are found to be similar to those associated with discrete auroras. Current theoretical pulsation models are discussed in light of the observations. (Pulsating aurora, particle pulsation, rocket-borne particle measurements.)
J. Geophys. Res., Blue, Paper 1A0255

5920 Electric Fields
THE PENETRATION OF CONVECTION ELECTRIC FIELDS TO THE LATITUDE OF MILLSTONE HILL ($\Lambda = 56°$)
R. W. Wand[Herzhauser Corporation, Westford, Massachusetts 01886) and J. V. Evans
Incoherent scatter observations of E- and F-region drifts over Millstone Hill ($\Lambda = 56°$) were made routinely from May 1976 to November 1977 at monthly intervals. Some 667 hours of data gathered over this 19-month period has been analyzed to yield the F-region polarization electric field in the magnetic south and magnetic east directions. In an effort to determine that part of the observed fields can be attributed to the penetration of auroral convection fields to the latitude of Millstone, these data have been used to construct an analytical model of these two field components having a time of day and K_p dependence [Wand, 1980]. To guide the interpretation, mean convection fields were also constructed for $\Lambda = 60°$, 65°, 70° and 75°, using data gathered between May 1978 and December 1978 from a separate series of experiments [Evans et al, 1979, 1980]. The results suggest that, under quiet magnetic conditions, there is no significant penetration of the magnetospheric electric field to the latitude of Millstone at any time of day except possibly for the southward component of the field at night. During magnetically disturbed periods, the incremental fields observed over Millstone exhibit all the gross characteristics associated with convection fields even at higher latitudes. The results also indicate an eastward rotation of the convection pattern of about 4 hours in local time in going from quiet or moderate conditions ($K_p \approx 2+$) at $\Lambda = 65°$ to disturbed conditions ($K_p \approx 5$) at $\Lambda = 56°$. (Ionosphere, electric fields, convection, magnetosphere).
J. Geophys. Res., Blue, Paper 1A0237

5930 High-latitude ionospheric currents
GLOBAL DISTRIBUTION OF THE PEDERSEN AND HALL CURRENTS AND THE ELECTRIC POTENTIAL PATTERN DURING A MODERATELY DISTURBED DAY
Y. Kamide (Kyoto Sangyo University, Kamigamo-Motoyama, Kita-ku, Kyoto 603, Japan) and S.-I. Akasofu
The distribution of the Pedersen and Hall currents and the electric potential pattern over the entire polar region is determined for the first time by using a computer code developed by Kamide, Richmond and Matsushita (1981) on the basis of magnetic field data obtained from the IMS Alaska meridian chain of observatories. In spite of the totally different principles used, the two methods result in similar large-scale distributions of the ionospheric currents and field-aligned currents, and the estimated values are in reasonable agreement with those observed more directly by radar and satellite techniques. Thus, ground-based magnetic field records, together with an advanced computer code for separating the contribution from ionospheric and field-aligned currents, are proven to be a powerful tool in studying the substorm current system, providing a complete set of information on the global distribution of ionospheric currents, electric fields and of field-aligned currents, as well as the convection pattern. There are, however, some differences which are mostly intrinsic to each method. These are discussed in detail, in terms of advantages and disadvantages of each method.
J. Geophys. Res., Blue, Paper 1A0228

5930 High-latitude ionospheric currents
COMPARISON OF TWO MODELING METHODS FOR THREE-DIMENSIONAL CURRENT SYSTEMS
S.-I. Akasofu (Geophysical Institute, University of Alaska, Fairbanks, Alaska 99701) Y. Kamide and J. Kisabeth
Three-dimensional current systems in high latitudes are obtained by two independent methods on the basis of magnetic field data obtained from the IMS Alaska meridian chain of observatories. In spite of the totally different principles used, the two methods result in similar large-scale distributions of the ionospheric currents and field-aligned currents, and the estimated values are in reasonable agreement with those observed more directly by radar and satellite techniques. Thus, ground-based magnetic field records, together with an advanced computer code for separating the contribution from ionospheric and field-aligned currents, are proven to be a powerful tool in studying the substorm current system, providing a complete set of information on the global distribution of ionospheric currents, electric fields and of field-aligned currents, as well as the convection pattern. There are, however, some differences which are mostly intrinsic to each method. These are discussed in detail, in terms of advantages and disadvantages of each method.
J. Geophys. Res., Blue, Paper 1A0228

5345 Ionospheric disturbances
THE CURRENT CONVECTIVE INSTABILITY AS APPLIED TO THE AURORAL IONOSPHERE
P. K. Chaturvedi (Berkeley Research Associates, Springfield, Virginia 22150) and S. L. Ossakow
We extend the previous analysis of the current convective instability as applied to the diffuse auroral situation (Ossakow and Chaturvedi, 1978) to include ion inertial effects, important at high altitudes (and to the case in which ions have a finite collisional (non-magnetized), a situation which is realized at F-region altitudes. In the inertial domain the instability growth rates are comparable to those found in the collision dominated domain. This extends the applicability of the instability process to high altitudes. The relevance of the instability to the E-region is discussed. Finally, electromagnetic effects, which can be important for long wavelengths, are considered and are found to be small in ionospheric situations. (Plasma instability, currents, gradients, diffuse aurora).
J. Geophys. Res., Blue, Paper 1A0183

Izvestiya Physics of the Solid Earth

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CONTENTS

SCIENTIFIC COMMUNICATIONS

Physical Properties of Rocks

6140 Magnetic and electrical properties
A SELF-CONSISTENT MODEL FOR SEDIMENTARY ROCKS WITH APPLICATION TO THE DIELECTRIC CONSTANT OF FUSED GLASS BEADS
P.N. Sen (Schlumberger-Doll Research, P.O. Box 307, Ridgefield, CT 06877) C. Scala and M. H. Cohen
We develop a theory for dielectric response of water-saturated rocks based on a realistic model of the pore space. The absence of a percolation threshold manifest in Archie's law, porosities, electron-micrographs, and general theories of formation of detrital sedimentary rocks indicates that the pore spaces within such rocks remain interconnected to very low values of the porosity ϕ. In the simplest geometric model for which the conductivity pathe remain interconnected, each grain is envisioned to be coated with water. The dielectric constant of the assembly of water-coated grains is obtained by a self-consistent effective medium theory. In the dc limit, this gives Maxwell's relation for conductivity of the rock $\sigma = \frac{3}{4}\sigma_w(\phi - 0)$, where σ_w is the conductivity of water. In order to include the local environmental effects around a grain, a self-similar model is generated by envisioning that each rock grain itself is coated with a skin made of other coated spheroids; the coating at each level consists of other coated spheroids. The self-consistent complex dielectric constant ϵ^* is given in this model in terms of that of water, ϵ_w^* and of rock, ϵ_r^*, by $(\epsilon_w^* - \epsilon^*)/(\epsilon_w^* + 2\epsilon^*)\phi^{1/3} = 0$ for spherical particles. This gives in the dc limit, $\sigma = \sigma_w\phi^{3/2}$. For nonspherical particles, the exponent m in Archie's law $\sigma = \sigma_w\phi^m$ is greater than 3/2 for the plate-like grains or cylinders with axis perpendicular to the external field and smaller than 3/2 for plates or cylindrical particles with axis parallel to the external field. Artificial rocks with a wide range of porosities were made from glass beads. We present data on the glass bead rocks for dc conductivity and dc dielectric constant at 1.1 GHz. The data follow the conductivity and the dielectric responses given by the self-similar model. The present theory fails to explain the salinity dependence for ϵ^* at lower frequencies.
Geophysics, Vol. 46, No. 5

Seismology

6905 Body waves
HIGHER TRANSITIONS IN SEISMIC INTERPRETATION
E.L.N. Kennett (CIRES, University of Colorado/NOAA, Boulder, CO 80309)
Wave propagation in a horizontally stratified medium may be characterized by the slowness of the waves. In ray theory the travel-time curves are parametrized by the slowness, and this dependence is exploited in modern methods of ray inversion for crustal models. This 'complete' response of a stratified medium may also be represented as a superposition of cylindrical waves of varying slowness. This representation leads to the possibility of presenting the response of the stratification in a slowness-time map containing both travel time and amplitude information. Such an approach requires complete good quality data but offers advantages in interpretation. Even in the presence of lateral variations of structure, slowness methods can provide useful information.
J. Geophys. Res., Red, Paper 1B0244

6905 Body waves
HIGH-FREQUENCY Pn,Sn VELOCITIES: SOME COMPARISONS FOR THE WESTERN, CENTRAL, AND SOUTH PACIFIC
D. Walker (Hawaii Institute of Geophysics, University of Hawaii, 2525 Correa Rd., Honolulu, Hawaii 96822)
High-frequency Pn,Sn velocities for earthquakes originating in the subduction zones of the Western Pacific suggest that the travel paths of these phases, recorded in the range of 17° to 25°, can be significantly different from those of Pn,Sn phases recorded at distances less than 15° or greater than 35°. This suggestion is supported by high-frequency Pn,Sn velocities for intra-plate earthquakes in the Central and South Pacific.
Geophys. Res. Lett., Paper 1L0129

6950 Seismic sources (mechanisms, magnitude, frequency spectrum, space, and time distribution)
THE 1978 NOVEMBER 29, OAXACA, MEXICO EARTHQUAKE — A LARGE SIESMIC EVENT
G. V. Stewart, (Seismological Laboratory, California Institute of Technology, Pasadena, California 91125) E. P. Chael and K. C. McNally
The recent Oaxaca, Mexico earthquake 1978 November 29 ($M_L = 7.6$, $M_s = 7.8$, seismic moment, $M_o = 3.2 \times 10^{27}$ dyne-cm), is of special interest because of its location within a pre-determined seismic gap. The event excited long-period (120–200 sec) multiple Rayleigh and Love waves which were well-recorded by the WWSSN. These data along with P-wave first-motion data and P waveforms were used to constrain the source mechanism. The source mechanism is a low-thrust mechanism consistent with subduction of the Cocos plate to the northeast beneath Mexico (dip = 18°, strike = N 60°E, rake = 90°). Hence this event is indeed of the type anticipated by Ohtake et al. (1977). A local network of seismometers, installed in a joint University of Mexico-California Institute of Technology program, began operation 20 days prior to the main shock (Gonzalez (1979), McNally et al. (1980) and Ponce et al. (1980)). 43 foreshocks of magnitude $M \geq 2.8$ were recorded by the network in a period of 20 days prior to the mainshock. These events show an interesting spatial and temporal pattern, which culminates in the last 1.8 days of the sequence with an apparent migration of activity towards the epicenter of the impending earthquake. This pattern can be interpreted as a buildup of stress or migration of stress towards a fault zone asperity.
With supplemental stations, the network continued operation until 15 December 1978 (Singh et al. (1980)) and provided good hypocentral control for the more than 180 aftershocks of magnitude $M \geq 2.8$. The area of the aftershock zone determined from these events is 5525 km^2 (65 km by 85 km). In spite of the large size of the event, P-waves for the Oaxaca event indicate an extremely simple source, at the period range. of the WWSSN long-period seismographs. This simplicity suggests that the P-waves were generated by a limited portion of the rupture surface, perhaps by the breaking of a fault zone asperity. This result may be further supported by the discrepancy between the larger surface wave inversion for crustal stress. The complete response of a stratified medium may also be represented as a superposition of cylindrical waves of varying slowness. This representation leads to the possibility of presenting the response of the stratification in a slowness-time map containing both travel time and amplitude information. Such an approach requires complete good quality data but offers advantages in interpretation. Even in the presence of lateral variations of structure, slowness methods can provide useful information.
J. Geophys. Res., Red, Paper 1B0244